USB 3.0 ENGINEERING CHANGE NOTICE

ECN# 006

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USB 3.0 ENGINEERING CHANGE NOTICE

Title: USB3.0 State Machines ECN

Applied to: USB3.0 (11132008)-final

Brief description of the functional changes:
Consolidate the peripheral and hub state diagrams into a single figure, and update state machine to better match text. Correct USPORT state machine to better match text. Replace PCONNECT state machine with an Upstream Device Port (USDPORT) state machine that is consistent with the format of the (hub) USPORT state machine. Update supporting text. Add OTG specific Port Capability LMP, Device Notification Type, Feature selector requirements. Clarify device state that must be saved while a device is suspended.

Benefits as a result of the changes:
Clarifies spec and updates state machine figures to reflect latest spec changes.

An assessment of the impact to the existing revision and systems that currently conform to the USB specification:
Figure and text updates/clarifications to match existing revision text. No changes to current systems.

An analysis of the hardware implications:
Applies to all USB devices, including OTG.

An analysis of the software implications:
Applies to all USB devices, including OTG.

An analysis of the compliance testing implications:
Within scope of current compliance tests.

Actual Changes

(a). Amendments to Section 8.4.6

Replace following line:

"If the port that was to be configured in the upstream facing mode does not receive this LPM within tPortConfiguration time after link initialization, then the upstream port shall transition to SS.Disabled and it shall try and connect at other speeds this device supports."

with:

"If the port that was to be configured in the upstream facing mode does not receive this LMP within tPortConfiguration time after link initialization, then the upstream port shall transition to SS.Disabled and ~~it~~a peripheral device shall try and connect at other speeds this device supports.:

(b). Amendments to Section 9.1.1(Figure 9-1/9-2)

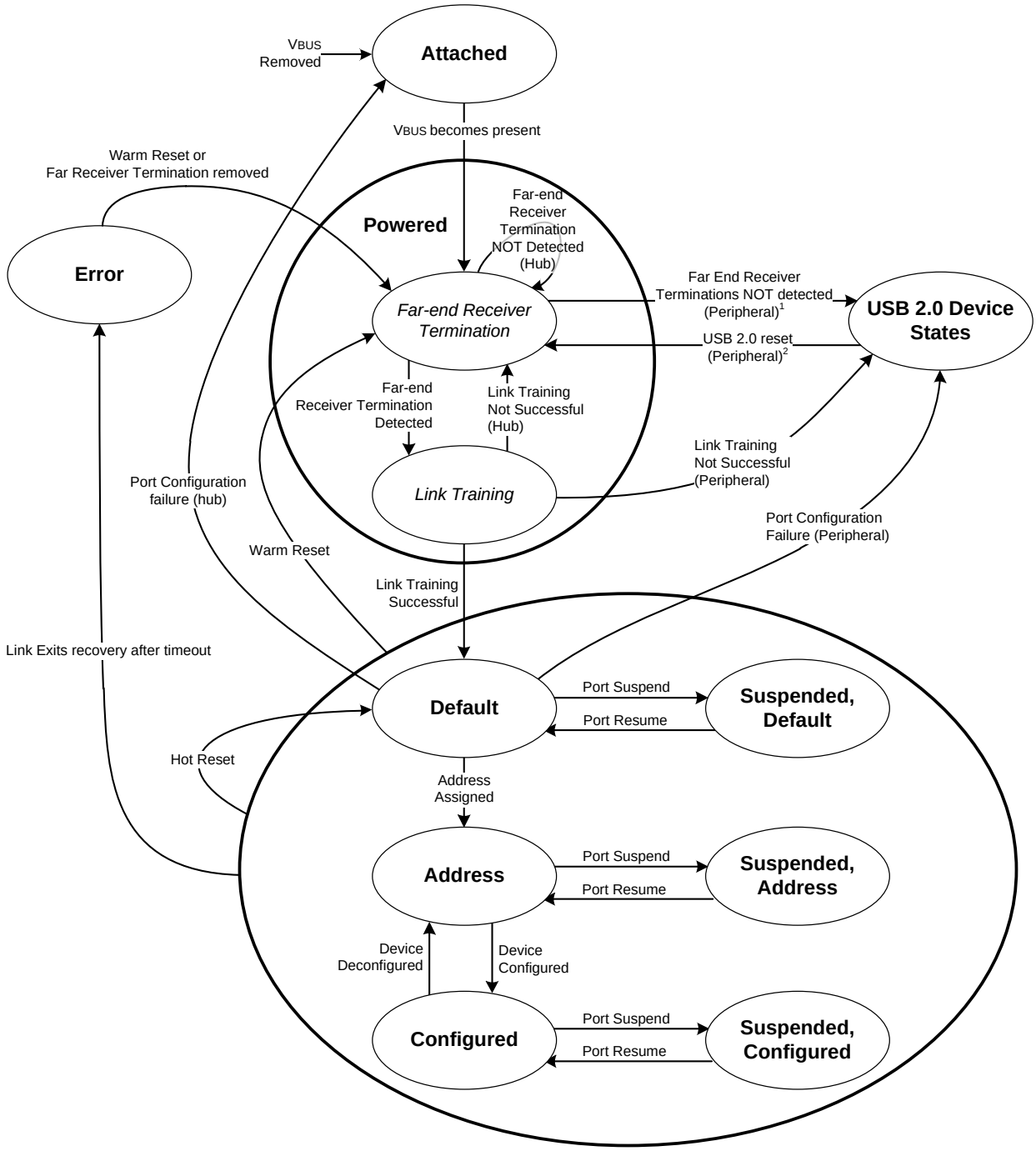
Update section and figure to reflect discrepancies identified by the OTG WG and clean-up references to the state that must be saved during suspend.

9.1.1 Visible Device States

This section describes device states that are externally visible (see Combined Figure 9-1). Table 9-1 summarizes the visible device states.

NOTE

Devices perform a reset operation in response to reset signaling on the upstream facing port. When reset signaling has completed, the device is reset. The reset signaling depends on the link state. Refer to Section 7.3 for details.



[1] Refer to Note 2 in Figure 10-25 Peripheral Device Upstream Port State Machine.
[2] Refer to sections 10.16.2.6 and 10.16.2.7 for the conditions that cause this transition.

Figure 9-1. Peripheral State Diagram & Hub State Diagram (SuperSpeed Portion only)

Figure 9-1 is a combined state diagram for both peripherals and hubs. Note that a USB 3.0 Hub has two discrete state diagrams, one for the SuperSpeed portion shown in Figure 9-1 and another for the non-SuperSpeed portion which may be found in Figure 9-1 in the USB 2.0 Specification.

Table 9-1. Visible SuperSpeed Device States

Attached	Powered	Default	Address	Configured	Suspended[1]	Error	State
No	--	--	--	--	--	--	Device is not attached to the USB. Other attributes are not significant.
Yes	No	--	--	--	--	--	Device is attached to the USB, but is not powered. Other attributes are not significant.
Yes	Yes	No	--	--	--	--	Device is attached to the USB and powered and its upstream link has not successfully completed training.
Yes	Yes	Yes	No	--	--	--	Device is attached to the USB and powered and has been reset, but has not been assigned a unique address. Device responds at the default address.
Yes	Yes	Yes	Yes	No	--	--	Device is attached to the USB, powered, has been reset, and a unique device address has been assigned. Device is not configured.
Yes	Yes	Yes	Yes	Yes	No	--	Device is attached to the USB, powered, has been reset, has a unique address, is configured, and is not suspended. The host may now use the function provided by the device.
Yes	Yes	Yes	--	--	Yes	--	Device is, at minimum, in the Default State (attached to the USB, is powered and its upstream link has been successfully trained) and its upstream link has been set to U3 by its upstream link partner. It may also have a unique address and be configured for use. However, because the device is suspended, the host may not use the device's function.
Yes	Yes	--	--	--	--	Yes	Device is attached to the USB, powered, and a link timeout error has occurred.

[1] Suspended from the Default, Address, or Configured state.

9.1.1.1 Attached

A device may be attached or detached from the USB. The state of a device when it is detached from the USB is not defined by this specification. This specification only addresses required operations and attributes once the device is attached.

9.1.1.2 Powered

Devices may obtain power from an external source and/or from the USB through the hub to which they are attached. Externally powered devices are termed self-powered. Although self-powered devices may already be powered before they are attached to the USB, they are not considered to be in the Powered state until they are attached to the USB and VBUS is applied to the device.

A device may support both self-powered and bus-powered configurations. Some device configurations support either power source. Other device configurations may be available only if the device is self-powered. Devices report their power source capability through the configuration descriptor. The current power source is reported as part of a device's status. Devices may change their power source at any time, e.g., from self- to bus-powered. If a configuration is capable of supporting both power modes, the power maximum reported for that configuration is the maximum the device will draw from VBUS in either mode. The device shall observe this maximum, regardless of its mode. If a configuration supports only one power mode and the power source of the device changes, the device will lose its current configuration and address and return to the Powered state. If a device operating in SuperSpeed mode is self-powered and its current configuration requires more than 150 mA, then if the device switches to being bus-powered, it shall return to the Powered state. Self-powered hubs that use VBUS to power the Hub Controller are allowed to remain in the Configured state if local power is lost. Note that the maximum power draw for a SuperSpeed device operating in non-SuperSpeed mode is governed by the limits set in the USB 2.0 specification.

A hub port shall be powered in order to detect port status changes, including attach and detach. Bus-powered hubs do not provide any downstream power until they are configured, at which point they will provide power as allowed by their configuration and power source. A device shall be able to be addressed within a specified time period from when power is initially applied (refer to Chapter 7). After an attachment to a port has been detected, the host may reset the port, which will also reset the device attached to the port.

While in the Powered state, a hub or peripheral device may be in one of two substates; "Far-end Receiver Termination" or "Link Training".

9.1.1.2.1 Far-end Receiver Termination Substate

A peripheral device shall transition to USB 2.0 Device States as per the conditions defined in Note 2 of Figure 10-25, if Far-end Receiver Terminations are not detected.

A hub shall remain in the Far-end Receiver Termination substate, if Far-end Receiver Terminations are not detected.

If Far-end Receiver Terminations are detected, a hub or peripheral device shall transition to the Link Training substate.

9.1.1.2.2 Link Training Substate

A peripheral device shall transition to USB 2.0 Device States, if Link Training fails.

A hub shall transition to the Far-end Receiver Termination substate, if Link Training fails.

If Link Training is successful, a hub or peripheral device shall transition to the Default state.

9.1.1.3 Default

When operating in SuperSpeed mode, after the device has been powered, it shall not respond to any bus transactions until its link has successfully trained. The device is then addressable at the default address.

A device that is capable of SuperSpeed operation determines whether it will operate at SuperSpeed as a part of the connection process (see the Device Connection State Diagram in Chapter 10 for more details).

A USB 3.0 device shall reset successfully at one of the supported USB 2.0 speeds when in an USB 2.0 only electrical environment. After the device is successfully reset, the device shall also respond successfully to device and configuration descriptor requests and return appropriate information according to the requirements laid out in the USB 2.0 specification. The device may or may not be able to support its intended functionality when operating in the USB 2.0 mode.

A peripheral device shall transition to USB 2.0 Device States, if Port Configuration fails. Refer to section 8.4.5.

A hub shall transition to the Attached state if Port Configuration fails. Note that it is necessary to physically remove and reapply Vbus to transition a hub out of the Attached state.

9.1.1.4 Address

All devices use the default address when initially powered or after the device has been reset. Each device is assigned a unique address by the host after reset.

A device responds to requests on its default pipe whether the device is currently assigned a unique address or is using the default address.

9.1.1.5 Configured

Before a device's function may be used, the device shall be configured. From the device's perspective, configuration involves correctly processing a SetConfiguration() request with a nonzero configuration value. Configuring a device or changing an alternate setting causes all of the status and configuration values associated with all the endpoints in the affected interfaces to be set to their default values. This includes resetting the sequence numbers of any endpoint in the affected interfaces to zero. On initial entry into the configured state a device shall default into the fully functional D0 State.

9.1.1.6 Suspended

In order to conserve power, devices automatically enter the Suspended state (one of Suspended Default, Address, or Configured) when they observe that their upstream link is being driven to the U3 state (refer to Section 7.2.4.2.4). Refer to section 9.2.5.2 for the state that a device maintains while it is suspended.

Attached devices shall be prepared to suspend at any time from the Default, Address, or Configured states. A device shall enter the Suspended state when the hub port it is attached to is set to go into U3. This is referred to as selective suspend.

A device exits suspend mode when it observes wake-up signaling (refer to Section 7.5.9) on its upstream port. A device may also request the host to exit suspend mode or selective suspend by driving resume signaling (refer to Section 7.5.9) and sending a Function Wake Notification (refer to Section 8.5.6) on its upstream link to indicate remote wakeup. The ability of a device to signal remote wakeup is optional. If a device is capable of remote wakeup, the device shall support the ability of the host to enable and disable this capability. When the device is reset, remote wakeup shall be disabled. Refer to Section 9.2.5 for more information.

9.1.1.7 Error

This state is entered if the device is in the Default, Address, Configured, or Suspended state and its link exits the Recovery state due to a timeout. A Warm Reset or removal of Far-end Receiver Terminations shall recover from this error condition and transition the device to the Powered:Far-end Receiver Termination substate.

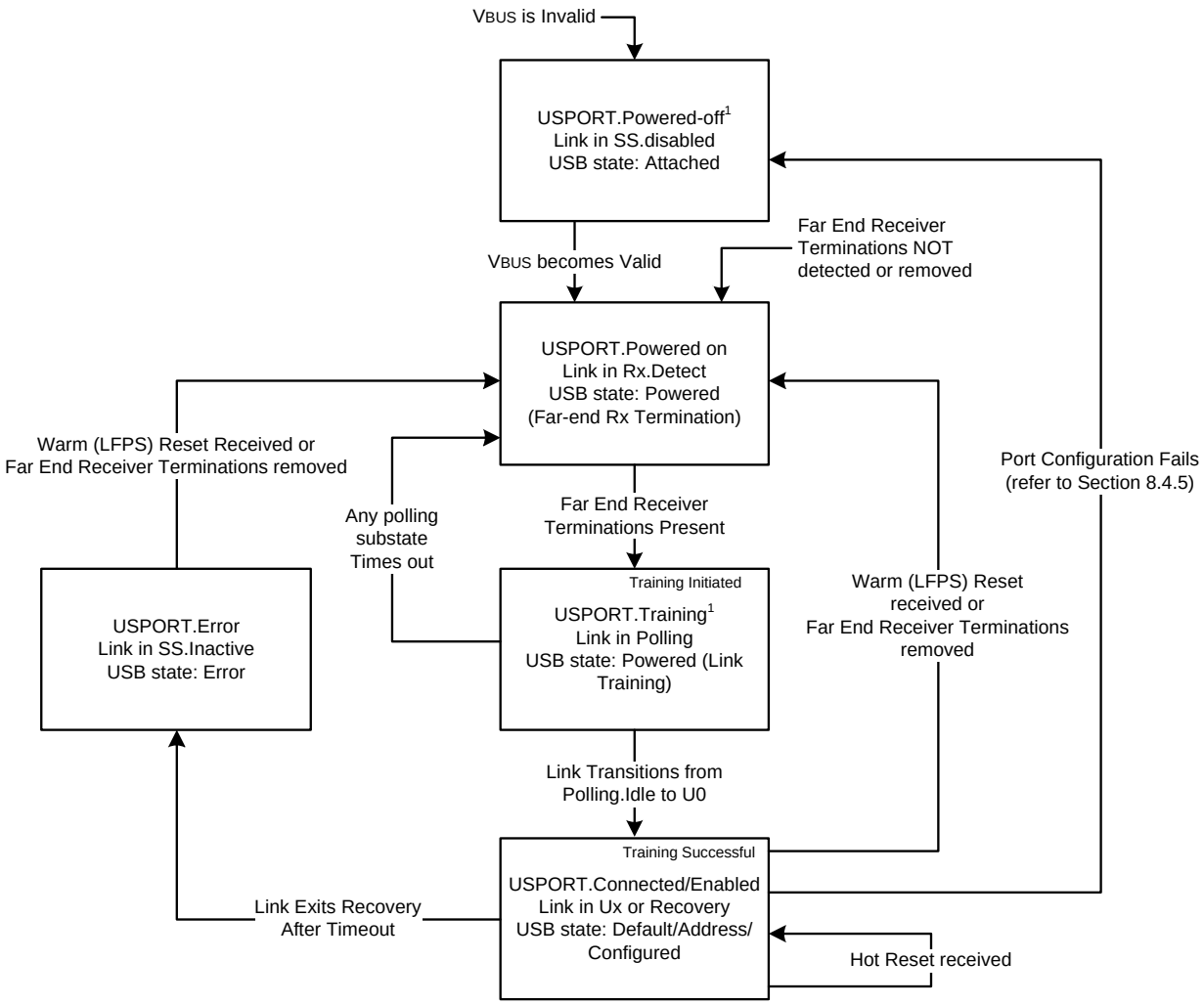
(c). Amendments to Figure 10-9

Add footnote to “Disconnected Detected[1]” transition into the DSPORT.Disconnected state:

[1]This direct transition may only occur from a DSPORT state whose link in the SS.Inactive, U1, U2, or U3 state.

(d). Amendments to Section 10.5 (Figure 10- 11)

Replace current Figure 10-11 in Section 10.5 with the figure below:



[1] If Port Configuration fails, the port shall transition to the USPORT.Powered-off state with the link in SS.Disabled state and USB Device in the Attached state. Vbus may still present on the upstream port. Vbus must be toggled to transition to the USPORT.Powered on state.

Changes to the text for Section 10.5 are redlined below:

10.5.1 Upstream Facing Port State Descriptions

Refer to Figure 9-1 for hub USB states.

10.5.1.1 USPORT.Powered-off

The USPORT.Powered-off state is the default state for an upstream facing port.

A port shall transition into this state if any of the following situations occur:

- From any state when VBUS is invalid.
- From any state if far-end receiver terminations are not detected.
- From the USPORT.Connected/Enabled state if the Port Configuration process fails.

In this state, the port's link shall be in the SS.Disabled state and the corresponding hub USB state shall be Attached.

10.5.1.2 USPORT.Powered-on

A port shall transition into this state in any of the following situations:

- From the USPORT.Powered-off state when VBUS becomes valid.
- From the USPORT.Error state when the link receives a warm reset or if Far-end Terminations are removed.
- From the USPORT.Connected/Enabled state when the link receives a Warm Reset.From the USPORT.Training state if the port's link times out from any Polling substate.

In this state, the port's link shall be in the Rx.Detect state. The corresponding hub USB state shall be Powered (Far-end Receiver Termination substate). While in this state, if the USB 2.0 portion of the hub enters the suspended state, the total hub current draw from VBUS shall meet the suspend current limit.

10.5.1.3 USPORT.Training

A port transitions to this state from the USPORT.Powered-on state when SuperSpeed far-end receiver terminations are detected.

In this state, the port's link shall be in the Polling state. The corresponding hub USB state shall be Powered (Link Training substate).

10.5.1.4 USPORT.Connected/Enabled

A port transitions to this state from the USPORT.Training state when its link enters U0 from Polling.Idle. A port remains in this state during hot reset. When a hot reset is completed, the corresponding hub USB state shall transition to Default.

In this state, the port's link shall be in the U0, U1, U2, U3, or Recovery state. The corresponding hub USB state shall be Default, Address, or Configured.

When the link enters U0 the port start the port configuration process as defined in 8.4.5.

The port may send link management packets or link commands but shall not transmit any other packets except to respond to default control endpoint requests while in the USPORT.Connected state.

10.5.1.5 USPORT.Error

A port transitions to this state when a serious error condition occurred while attempting to operate the link. A port transitions to this state in any of the following situations:

- From the USPORT.Connected/Enabled state if the link enters Recovery and times out without recovering.

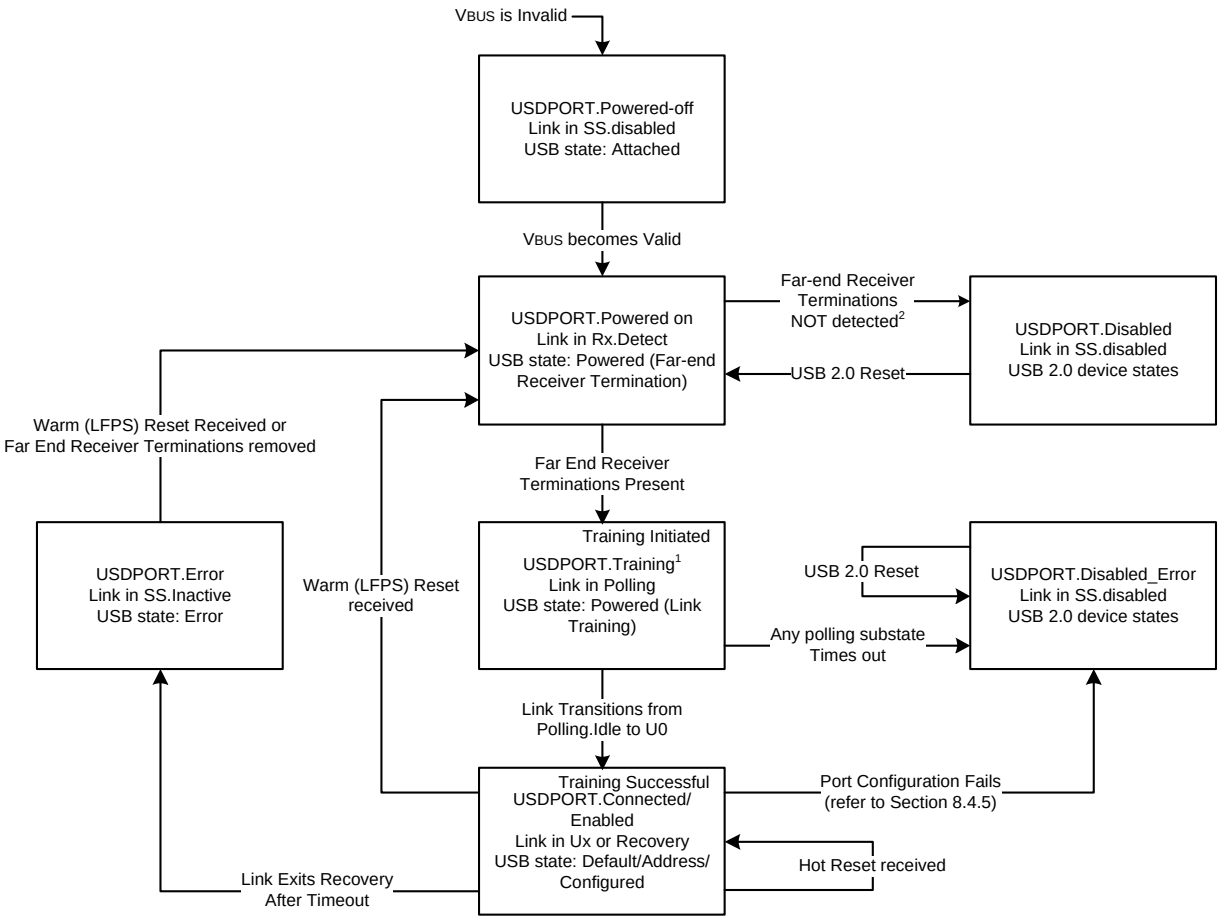
In this state, the port's link shall be in the SS.Inactive state. The corresponding hub USB state shall be Error.

A port exits the Error state only if a Warm Reset is received on the link or if Far-end Receiver Terminations are removed.

(e). Amendments to Section 10.16.2 (Figure 10-25)

10.16.2 Peripheral Device Upstream Port State Machine

The following sections provide a functional description of a state machine that exhibits correct peripheral device behavior for when to connect on SuperSpeed or USB 2.0. Figure 10-25 is an illustration of the peripheral device upstream port state machine.



[1] Peripheral Device must disconnect on USB2.0 within tUSB2SwitchDisconnect of entering this state
[2] If USPORT.Powered on was entered from any state except USPORT.Disabled then this transition shall take place if Far-end Receiver Terminations (RRX-DC) are not detected after 8 successive Rx.Detect.Quiet to Rx.Detect.Active transitions. If USPORT.Powered on was entered from the USPORT.Disabled state, then this transition shall take place the first time that Far-end Receiver Terminations are not detected in the Rx.Detect.Active substate.

Figure 10-15. Peripheral Upstream Device Port State Machine

10.16.2.1 USDPORT.Powered-off

The USDPORT.Powered-off state is the default state for a peripheral device. A peripheral device shall transition into this state if any of the following situations occur:

- From any state when VBUS is invalid.

In this state, the port's link shall be in the SS.Disabled state and the USB 2.0 pull-up is not applied. The corresponding peripheral USB state shall be Attached.

10.16.2.2 USDPORT.Powered on

A port shall transition into this state if any of the following situations occur:

- From the USDPORT.Powered-off state when VBUS becomes valid (and local power is valid if required).
- From the USDPORT.Error state when the link receives a warm reset or Far-end terminations are removed.
- From the USDPORT.Connected/Enabled state when the link receives a Warm Reset.
- From the USDPORT.Disabled state if the port receives a USB2.0 reset.

In this state, the port's link shall be in the Rx.Detect state. The corresponding peripheral device USB state shall be Powered (Far-end Receiver Termination substate).

If the transition is from the USDPORT.Disabled state the USB 2.0 pull-up shall remain enabled. If the transition is from any other state the USB 2.0 pull-up shall not be enabled.

10.16.2.3 USDPORT.Training

A port transitions to this state from the USDPORT.Powered-on state when SuperSpeed Far-end Receiver Terminations are detected.

In this state, the port's link shall be in the Polling state. The corresponding peripheral device USB state shall be Powered (Link Training substate).

As noted in Figure 10-25, the peripheral device shall disconnect on USB2.0 within tUSB2SwitchDisconnect after entering this state.

10.16.2.4 USDPORT.Connected/Enabled

A port transitions to this state from the USDPORT.Training state when its link enters U0 from Polling.Idle. A port remains in this state during hot reset. When a hot reset is completed, the corresponding peripheral device USB state shall transition to Default.

In this state, the SuperSpeed link is in U0, U1, U2, U3 or Recovery and the USB 2.0 pull-up is not applied. The corresponding peripheral device USB state shall be Default, Address, or Configured.

10.16.2.5 USDPORT.Error

A port transitions to this state when a serious error condition occurred while attempting to operate the link. A port transitions to this state if the following situation occurs:

From the USDPORT.Connected/Enabled state if the link enters Recovery and times out without recovering.

In this state, the port's link shall be in the SS.Inactive state. The corresponding peripheral device USB state shall be Error.

A port exits the USDPORT.Error state only if a Warm Reset is received on the link or if Far-end Receiver Terminations are removed.

10.16.2.6 USDPORT.Disabled

A port transitions to this state from the USDPORT.Powered on state when Far-end Receiver Terminations are not detected as per the rules described below:

If USDPORT.Powered on was entered from any state except USDPORT.Disabled then this transition shall take place if Far-end Receiver Terminations (RRX-DC) are not detected after 8 successive Rx.Detect.Quiet to Rx.Detect.Active transitions.

If USDPORT.Powered on was entered from the USDPORT.Disabled state, then this transition shall take place the first time that Far-end Receiver Terminations are not detected in the Rx.Detect.Active substate.

In this state, the port's link shall be in the SS.Disabled state. The corresponding peripheral device USB state shall USB2.0 Device States.

10.16.2.7 USDPORT.Disabled_Error

A port transitions to this state from the USDPORT.Training state if the port's link times out from any Polling substate. The port shall remain in USDPORT.Disabled_Error state if the port's link receives a USB2.0 reset.

In this state, a fatal error has been detected on the port's link and the link shall be in the SS.Disabled state. The corresponding peripheral device USB state shall be USB2.0 Device States.

(f). Amendments to Section 8.4.5 (Table 8-7)

Add an OTG flag to DWORD 1 of the Port Capability LMP. This bit is asserted if a device supports an OTG USB3 role swap capability.

1	1:18	**USB 3.0 OTG Capable (OTG)**. This field shall be set to 1 if the port supports the OTG Capability. Refer to section 6.4 of the *On-The-Go and Embedded Host Supplement to the USB 3.0 Specification (Revision 3.0)* for more information.
1	1:19	**Reserved (R)**.

(g). Amendments to Section 8.4.1 (Table 8-3)

Reserve Device Notification TP **Notification Type** value for OTG use.

4	1:4	**Notification Type**. This field identifies the type of the device notification.

		Value	Type of Device Notification TP
		0000b	Reserved
		0001b	FUNCTION_WAKE
		0010b	LATENCY_TOLERANCE_MESSAGE
		0011b	BUS_INTERVAL_ADJUSTMENT_MESSAGE
		0100b	HOST_ROLE_REQUEST[1]
		0101b-1111b	Reserved

Add footnote to Table 8-3:

[1] This **Notification Type** value shall be reserved for OTG use. Refer to section 6.4 of the *USB 3.0 OTG and EH Supplement* for the definition of the respective Link Management Packet (LMP).

(h). Amendments to Section 1.7

Add OTG 3.0 supplement reference to *Related Documents* section.

USB On-the-Go and Embedded Host Supplement to the USB 3.0 Specification, Revision 1.0

(i). Amendments to Section 9.4, Table 9-6

Add OTG 3.0 feature selector after last row of Table 9-6.

B3_NTF_HOST_REL [1]	Device	51

Add footnote to Table 9-6:

[1] This Feature Selector value shall be reserved for OTG use. Refer to section 6.4 of the *USB 3.0 OTG and EH Supplement* for its definition.

(j). Amendments to Section 2

Add following terms to Terms and Abbreviations.

DSPORT	Notation indicating the state machine of a downstream facing port of a hub. Refer to section 10.3
USDPORT	Notation indicating the state machine of the upstream facing port of a peripheral device. Refer to section 10.16.

USPORT	Notation indicating the state machine of the upstream facing port of a hub. Refer to section 10.5.

(j). Amendments to Section 9.4, Table 9-6

Update section 9.2.5.2 as follows:

9.2.5.2 Changing Device Suspend State

Device suspend is entered and exited intrinsically as part of the suspend entry and exit processes (refer to Section 10.8). The minimum device state information that shall be maintained through the duration of each Suspended USB Device State is listed below:

Figure 9-?. Preserved USB Suspend State Parameters

Parameter	Suspended USB Device state[1, 2]	
	Address	Configured
U1_SEL/U1_PEL/U2_SEL/U2_PEL	Yes	Yes
HALT_ENPOINT	N/A	Yes
FUNCTION REMOTE WAKEUP	Yes	Yes
Isochronous Delay	N/A	Yes
U2_Inactivity_Timeout	Yes	Yes
Force_LinkPM_Accept	Yes	Yes
U1/U2 Enable	Yes	Yes
LTM_ENABLE	Yes	Yes
Data Sequence	N/A	Yes
Hub Depth	Yes	Yes
Downstream U1_Inactivity Timeout/ U2_Inactivity Timeout (Applicable to hubs)	Yes	Yes
Port Configuration Information	Yes	Yes
Device Configuration/Interface Setting Information	N/A	Yes
Device Address	Yes	Yes
Header Sequence Number	Yes	Yes
Downstream port state	Yes	Yes

[1] No parameters other than HSN, are preserved in the *Default* Suspended USB Device State.

[2] "Yes" indicates a parameter that shall be preserved in the respective Suspended USB Device State.

Some additional Class specific device state information may also be retained during suspend.

A device shall send a Function Wake Notification after driving resume signaling (refer to Section 7.5.9). If the device has not been accessed for longer than tNotification (refer to Section 8.13) since sending the last Function Wake Notification, the device shall send the Function Wake Notification again until it has been accessed.

(k). Amendment to Section 8.4.5

Correct cross reference in first paragraph:

All ports shall send this LMP within tPortConfiguration time after completion of link initialization (refer to Section 7.2.4.1.1).

(l). Amendment to Section 7.5.6.2

7.5.6.2 bullet 11 Note 1st sentence refers to section 8.4.5 but still gives the impression that tPortConfiguration starts on entry to U0 rather than after initialization is completed. Section 7.2.4.1.1 says, “The link initialization refers to the initialization of a port once a link transitions to U0 from Polling, Recovery or Hot Restet. The initialization includes the Header Sequence Number Advertisements and the Rx Header Buffer Credit Advertisements between the two ports before a header packet can be transmitted.” The tPortConfiguration timer starts once this process is complete, not on entry to U0.

Correct text of 7.5.6.2. as follows:

Note: After entry to U0 and the successful completion of training and link initialization, both ports are required to exchange port capabilities information using Port Capability LMPs within tPortConfiguration time as defined in Section 8.4.5. If the port has not received a Port Capability LMP within tPortConfiguration time, a downstream port shall be directed to transition to SS.Inactive and an upstream port shall be directed to transition to SS.Disabled.